APOLLO SYSTEMS DEPARTMENT

GENERAL ELECTRIC

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TECHNICAL INFORMATION RELEASE

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FROM D. J. Grounds		TO J. A. Rummel, Ph. D. /SE2	
DATE 3/13/78	WORK ORDER REF:	WORK STATEMENT PARA: NAS9-15487	REFERENCE:

SUBJECT

User's Instructions for the Erythropoiesis Regulatory Model

The purpose of the model is to provide a method to analyze some of the events that could account for the decrease in red cell mass observed in crewmen returning from space missions.

The model is based on the premise that erythrocyte production is governed by the balance between oxygen supply and demand at a renal sensing site (Figure 1). Oxygen supply is taken to be a function of arterial oxygen tension, mean corpuscular hemoglobin concentration, oxy-hemoglobin carrying capacity, hematocrit, and blood flow. Erythrocyte destruction is based on the law of mass action. The instantaneous hematocrit value is derived by integrating changes in production and destruction rates and accounting for the degree of plasma dilution.

Dennis J Grounds

D. J. Grounds

(NASA-CR-160193) USER'S INSTRUCTIONS FOR THE ERYTHROPOIESIS REGULATORY MODEL (General Electric Co.) 42 p HC A03/MF A01 CSCL 06P

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ASD 4028

PROGRAM DESCRIPTION GUIDE

A. IDENTIFICATION

Program Name - Erythropoiesis Regulatory Model

Programmer and Bioengineer Contact - D. J. Grounds or J. I. Leonard, GE/TSSD, P. O. Box 58408, Houston, Texas, 77058.

Date of Issue - March 10, 1978

B. GENERAL DESCRIPTION

A mathematical model and digital computer simulation of the erythropoietic control system were developed to simulate long term dynamic changes in red cell mass as a result of various environmental and physiological stimuli, including those associated with bed rest and weightless spaceflight. The purpose of the model is to provide a method to analyze some of the events that could account for the decrease in red cell mass observed in crewmen returning from space missions.

C. USAGE AND RESTRICTIONS

Machine, Operating System, and Compiler Required - Univac 1110, EXEC 8, FORTRAN V

Peripheral Equipment Required - Time-Sharing Terminal, Tektronix 4010 Graphics Terminal

D. PARTICULAR DESCRIPTION

The model is based on the premise that erythrocyte production is governed by the balance between oxygen supply and demand at a renal sensing site (Figure 1). Oxygen supply is taken to be a function of arterial oxygen tension, mean corpuscular hemoglobin concentration, oxy-hemoglobin carrying capacity, hematocrit, and blood flow. Erythrocyte destruction is based on the law of mass action. The instantaneous hematocrit value is derived by integrating changes in production and destruction rates and accounting for the degree of plasma dilution.

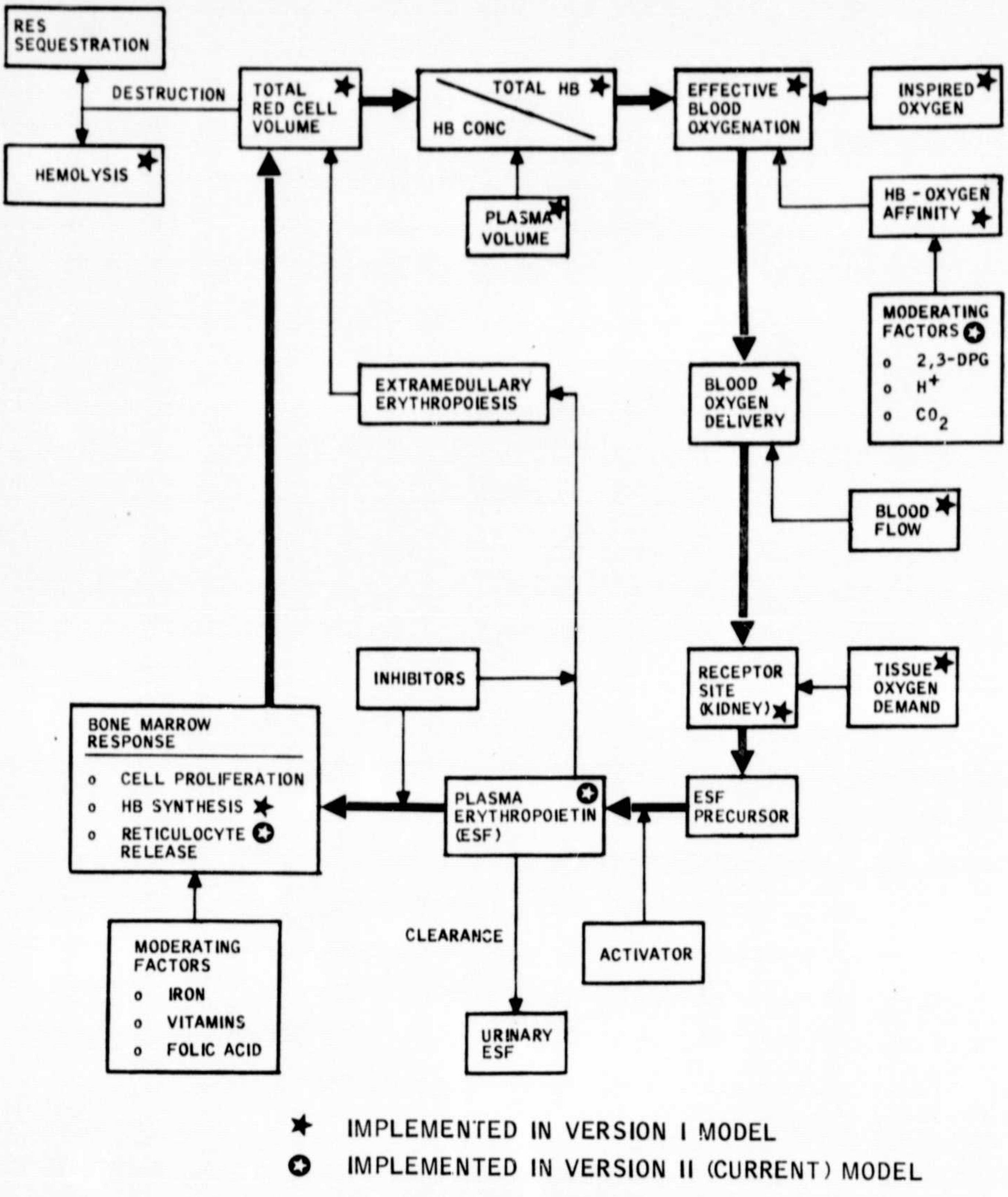

FIGURE 1

THE IMPROVED ERYTHROPOIESIS MODEL

The most significant improvement in the model is the explicit formulation of separate elements representing erythropoietin production and red cell production. Other modifications include bone marrow time-delays, capability to shift oxyhemoglobin affinity and an algorithm for entering experimental data as time-varying driving functions. These changes result in a significantly improved and more flexible model as demonstrated by consistently more realistic simulations.

A more detailed description of this model and the results of a validation study may be found in References 1-3.

The various types of simulations which can be performed with this model are illustrated in Table I.

In addition to these input parameters which can be changed to simulate experimental or clinical conditions, the model can be driven by experimental data for plasma volume or hematocrit. Data from experimental studies are available to the user upon demand. These studies will be listed under description of model input and the references appear in the Reference section.

E. DESCRIPTION OF INPUT

(1) Access procedures to the Univac 1110 have been documented in TIR 741-MED-3059 "Simplified user instructions for physiological models using the Univac 1110 in Demand Mode."

An example of input for the model is given in Appendix 1. This example contains all necessary responses after obtaining a carrier signal on the terminal.

(2) Execution of the program begins by typing @ADD THERM. LOADNEW. This instruction loads the appropriate programs into the user's file, compiles them, and collects them for execution. This process involves several lines of print before the program begins execution.

Initial conditions for the program are established by reading in a set of baseline values for the model parameters. The parameter names, definitions, and initial values and units are given in Appendix II. The mnemonics given in this glossary are the ones which must be used for specifying changes in input values or the output list, (see below).

(3) The user is given an option to use experimental data as input. If this option is exercised, the following choices are offered.

1 = Bed Rest Plasma Volume (Morse, 1969)
2 = Bed Rest Plasma Volume (Idealized)
3 = Bed Rest Plasma Volume (BCM-Johnson, 1976)
4 = Bed Rest HCT (BCM-Johnson, 1976)
5 = Altitude Hypoxia Plasma Volume (Buderer, 1973)
6 = Skylab 3 Plasma Volume
7 = Skylab 3 HCT (Peripheral)
8 = Skylab 4 Plasma Volume
9 = Skylab 4 HCT (Peripheral)
10 = Input Plasma Volume
11 = Input Peripheral Hematocrit

Upon selecting a study, the stored experimental data are written out.

(4) The user is then asked to specify the number of days for the run and the print interval.

The question INPUT WANTED CHANGED gives the user the opportunity to change any of the 67 model parameters listed in Appendix II. Some of the most meaningful parameters to change upon input are given in Table 1.

TABLE 1

INPUT PARAMETERS

Mnemonic		Definition
TMAX	=	time limit of run (days)
TPNT	=	print interval (days)
H	=	integration step size (min)
RCVO	=	initial red cell volume (liters)
PV	=	plasma volume (liters)
BF	=	blood flow (liters/min)
AOM	=	multiplier for changing basal oxygen consumption of renal tissue (ratio. to normal)
MCHC	=	mean corpuscular hemoglobin concentration (gm Hb/liter blood)

TABLE 1 (Continued)

INPUT PARAMETERS

Mnemonic		Definition
CHBO2	=	maximum oxygen carrying capacity of hemoglobin (ml O_2/gm Hb)
RKC	=	clearance time constant for red cell destruction (min^{-1})
PO2ART	=	arterial blood pO_2 (mm Hg)
G1	=	sensitivity or gain of erythropoietin releasing system to tissue pO_2
G2	=	sensitivity or gain of bone marrow to plasma erythropoietin concentration
EHL	=	erythropoietin half life (minutes)
ENIF	=	erythropoietin infusion (x normal volume)
RCVLO	=	volume labeled red cells infused (liters)

F. DESCRIPTION OF OUTPUT

The question OUTPUT WANTED or SAME gives the user the option to replace the output list with any specified parameter in the glossary. The default list is given in the example developed in Appendix I.

The model is set up to give graphical or tabular output on demand. If tabular output is selected, the user is guven the opportunity to plot the data in the output list after the tabular output is complete.

The graphics option permits the user to plot the model results using a TEKTRONIX 4010. Six (6) parameters may be selected from the eight selected output parameters. They are plotted against time in days and the loc (LOC) will break up the page into (2-6) separate plots.

The user is also required to specify the upper and lower coordinate limits (HIGH, LOW). A sample run illustrating this procedure is included in Appendix I.

G. INTERNAL CHECKS AND EXITS

The model will simulate desired experiment until time equals TMAX. The user will have an opportunity to:

a) continue the run by typing MORE
b) begin a new run by typing NEW
c) exit from execution mode by typing STOP

If you elect to continue the run (MORE) the present values of the input parameters will be printed and you may change any of them. The very least change that is required is to increase TMAX from its current value. Time is reset back to zero only when a NEW run is begun.

A normal stop exit occurs by typing "STOP" in response to "WISH TO CONtinue?"

H. INDEPENDENT SUBROUTINES

REDCEL	Main Program
INPUT	Initialization and conversational input
TISSUE	Computes tissue oxygen tension
BLOOD	Computes red cell mass
OUTPUT	Conversational output
INTGRL	Integration algorithm
GETSP	Oxy-hemoglobin saturation algorithm
PLOT	Graphics algorithms
XPER	Reads experimental data
DATA1-DATA 9	Experimental Data
BDAT	Initialization Data

I. SAMPLE RUNS

See Appendix I.

J. COMPUTER PROGRAM LISTING

See Appendix III.

REFERENCES

1. Leonard, J. I. "Study Report on Improvements and Validation of the Erythropoiesis Control Model for Bed Rest Stimulation," Technical Information Release, TIR 782-LSP-7012, General Electric Company, Houston, Texas, 1977.

2. Leonard, J. I., "Study Report - The Application of Systems Analysis and Mathematical Models to the Study of Erythropoiesis During Space Flight," Technical Information Release, TIR 741-MED-4012, General Electric Company, Houston, Texas, 1974.

3. Leonard, J. I. "Validation of a Model for Investigating Red Cell Mass Changes During Weightlessness," Technical Information Release, TIR 782-MED-6004, General Electric Company, Houston, Texas, 1976.

4. Morse, B. S. "Erythrokinetic Changes in Man Associated with Bed Rest." Lectures in Aerospace Medicine, 6th Series, School of Aerospace Medicine, Brooks AFB, Texas. pp. 240-254, 1967.

5. Buderer, M. C. and N. Pace. "Hemopoiesis in the Pig-Tailed Monkey Macaca Nemestrina During Chronic Altitude Exposure," Amer. J. Physiol. 223: 346-352, 1972.

6. Johnson, P. C. and T. Driscoll. "Red Cell Mass and Body Volume Changes After 28 Days of Bedrest," In: "Report of 28-Day Bedrest Simulation of Skylab," Volume II, P. C. Johnson and C. Mitchell (Eds., NASA Contract NAS9-14578, The Methodist Hospital, Houston, Texas, 1977.

7. Johnson, P. C., Driscoll, T. B., and A. D. LeBlane, "Blood Volume Changes," In: Proceedings Skylab Life Science Symposium, Vol. II, NASA TMX-58154, National Aeronautics and Space Administration, Lyndon B. Johnson Space Center, Houston, Texas, 77058, pp. 495-505, 1974.

APPENDIX I

EXAMPLE RUN

SIMULATION OF BED REST

```
TXL006
ENTER USERID/PASSWORD:
>








•DESTROY USERID/PASSWORD ENTRY
•UNIVAC 1100 OPERATING SYSTEM  VER. 31.244.214C (RSI)•
>@RUN,/N DG629,7007-0509-C,DB6-G03432,10
DATE: 030978       TIME: 150722
>@ADD THERM.LOADNEW
FURPUR 27R1 RL72-8 03/09/78 15:07:34
 1 SYM
 1 SYM
 1 SYM
 1 SYM
 1 SYM

•OUTPUT INTERRUPT•
@@X O
 1 SYM
>@XQT
   150 CARDS READ AS INPUT


                 ••MODEL FOR REGULATION OF ERYTHROPOIESIS••

 EXPERIMENTAL DATA WANTED? (Y/N)
>Y
 DO YOU WISH INSTRUCTIONS (Y/N)
>Y
 DATA CAN BE SELECTED FROM THE FOLLOWING STUDIES
 1= BEDREST PLASMA VOLUME (MORSE,1969)
 2= BED REST PLASMA VOLUME (IDEALIZED)
 3= BED REST PLASMA VOLUME (BCM-JOHNSON,1976)
 4= BEDREST HCT(BCM-JOHNSON,1976)
 5= ALTITUDE HYPOXIA PLASMA VOLUME (BUDERER,1973)
 6= SKYLAB 3 PLASMA VOLUME
 7= SKYLAB 3 HCT (PERIPHERAL)
 8= SKYLAB 4 PLASMA VOLUME
 9= SKYLAB 4 HCT (PERIPHERAL)
 10= INPUT PLASMA VOLUME
 11= INPUT PERIPHERAL HEMATOCRIT

 ENTER EXPERIMENTAL DATA CODE WANTED
>1
      .00    3.00    1.00    2.54   10.00    2.49   27.00    2.46   35.00    2.46
    36.00    2.70   50.00    2.70   60.00    3.03     .00     .00
```

```
 HARD COPY WANTED(Y,N)...
>N
<#

 DO YOU WISH TO PLOT BUFFERED DATA?  (Y/N CR)
>Y
<6D
<V$RL
 HARD COPY WANTED(Y,N)...
>N
<#
          GRAPHIC OUTPUT(Y,N,S),TIME INTERVALS,STARTX,STOPX,(A2,3F5.0)..
>Y   4.
 RCV                  Y SCALE   (A4,8X,F4.0,2F6.0)
 PLOT(Y,N,S) LOC HIGH  LOW    ...
>N
 BV                   Y SCALE   (A4,8X,F4.0,2F6.0)
 PLOT(Y,N,S) LOC HIGH  LOW    ...
>N
 HCT                  Y SCALE   (A4,8X,F4.0,2F6.0)
 PLOT(Y,N,S) LOC HIGH  LOW    ...
>Y           1.  49.   39.
 PO2TIS               Y SCALE   (A4,8X,F4.0,2F6.0)
 PLOT(Y,N,S) LOC HIGH  LOW    ...
>Y           2.  24.   19.
 PV                   Y SCALE   (A4,8X,F4.0,2F6.0)
 PLOT(Y,N,S) LOC HIGH  LOW    ...
>Y           1.  3.1   2.1
 D                    Y SCALE   (A4,8X,F4.0,2F6.0)
 PLOT(Y,N,S) LOC HIGH  LOW    ...
>N
 P                    Y SCALE   (A4,8X,F4.0,2F6.0)
 PLOT(Y,N,S) LOC HIGH  LOW    ...
>N
 ERY                  Y SCALE   (A4,8X,F4.0,2F6.0)
 PLOT(Y,N,S) LOC HIGH  LOW    ...
>NN
-

          GRAPHIC OUTPUT(Y,N,S),TIME INTERVALS,STARTX,STOPX,(A2,3F5.0)..
>
N
```

See Figure A-1

```
 WISH TO CONTINUE? (ENTER "NEW","MORE",OR "STOP", )
>STOP
```

```
 NO. DAYS WANTED,PRINT STEP
>10.,1.
 INPUT WANTED CHANGED,   END
 NAME  VALUE
 ----- ------------
>TMAX  11.
   2  TMAX    =  11.000   CHANGED FROM 11.000
>END
 OUTPUT WANTED OR SAME,STOP
 NAME
 ------
>STOP
 DO YOU WANT GRAPHIC INSTEAD OF TABULAR OUTPUT? (Y/N)
>N
```

DAYS	RCV	BV	HCT	PO2TIS	PV	D	P	ERY
.00	2.00	5.00	40.00	20.00	3.00	22.00	22.00	1.00
1.00	2.00	4.54	44.05	21.46	2.54	22.00	21.67	.91
2.00	2.00	4.53	44.09	21.52	2.53	21.99	20.45	.82
3.00	2.00	4.53	44.12	21.52	2.53	21.97	19.13	.80
4.00	1.99	4.52	44.13	21.53	2.52	21.93	18.01	.80
5.00	1.99	4.51	44.13	21.53	2.52	21.88	17.10	.80
6.00	1.98	4.50	44.13	21.53	2.51	21.82	16.39	.79
7.00	1.98	4.48	44.11	21.52	2.51	21.76	15.84	.79
8.00	1.97	4.47	44.09	21.52	2.50	21.69	15.41	.80
9.00	1.97	4.46	44.06	21.52	2.50	21.62	15.09	.80
10.00	1.96	4.45	44.03	21.50	2.49	21.55	14.84	.80
<V 11.00	1.95	4.44	43.97	21.47	2.49	21.48	14.66	.80

```
  TYPE SHIFT-OUT (SO) AND RETURN-->
```

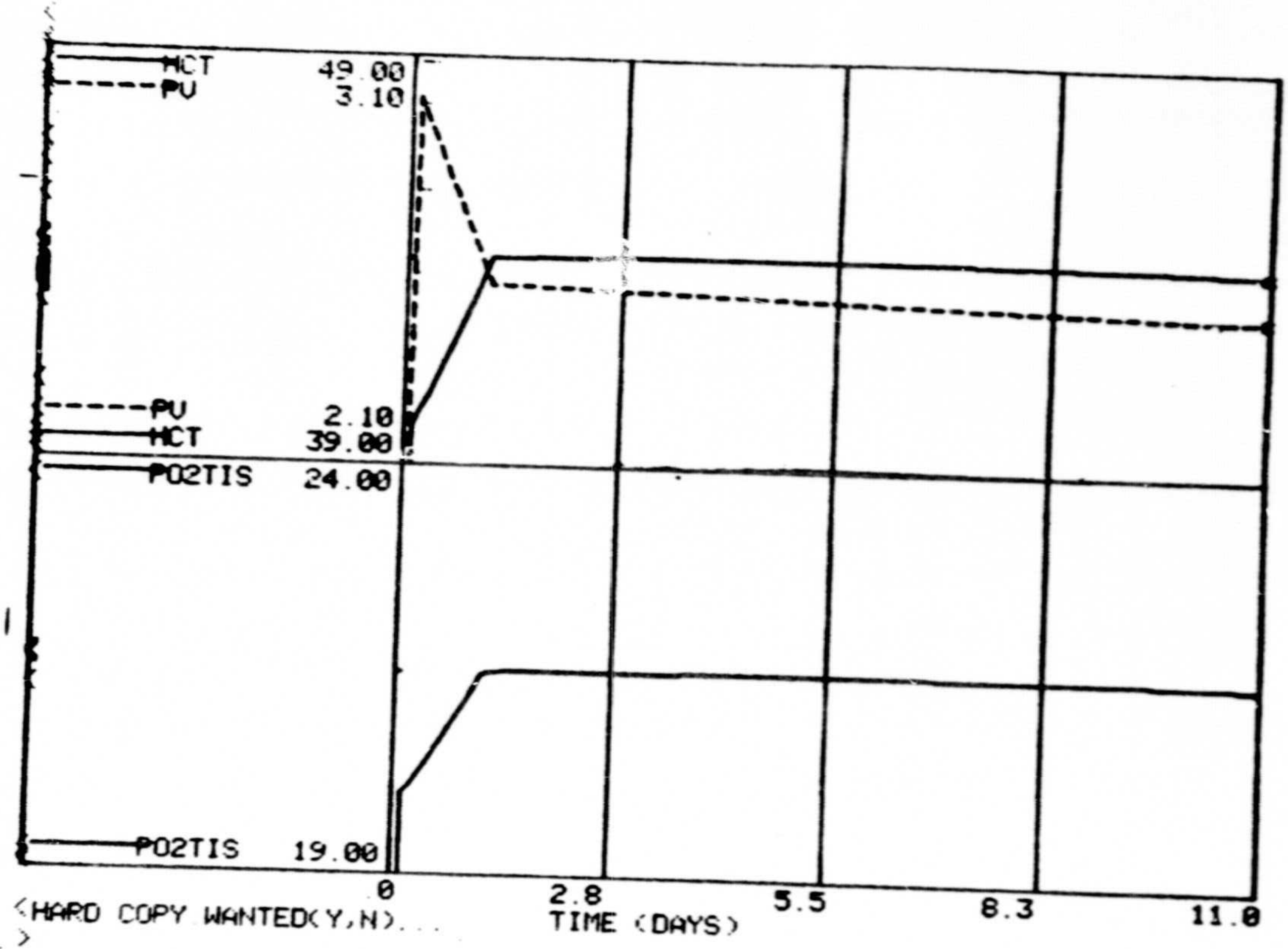

FIGURE A-1

EXAMPLE GRAPHICS OUTPUT

APPENDIX II

No.	Mnemonic	Initial Value	Definition
1	T	0.0	Time (mins.)
2	TMAX	0.0	Maximum time (days)
3	TPNT	1.0	Print Step (days)
4	H	1.0	Time Step (mins.)
5	BF	1.2	Renal blood flow (L/min)
6	PV	3.0	Plasma volume (liters)
7	RKC	7.6389E-06	Rate Constant RC Destruction Rate (l/min)
8	EGAIN	0.0	Not used
9	PO2DMD	-	" "
10	RCVO	2.0	Initial red cell volume (l)
11	VO20	0.032	
12	BMOTIS	20.0	Basal metabolic rate renal tissue (ml O_2/min)
13	AOM	1.0	Autonomic stim. effect on tissue O_2 Utilization (Normalized)
14	PO2ART	95.	PO_2 Arterial Blood (mm Hg)
15	QO2TIS	C	O_2 Delivery Rate to Renal Tissue (ml/min)
16	PO2TIS	C	O_2 Tension Renal Tissue (mm Hg)
17	STEP		Not Used
18	BV	5.0	Blood Volume (liters)
19	RCV	C	Red Cell Volume (liters)
20	HCT	C	Hematocrit whole-body
21	PROD	-	Not used
22	RCD	-	Red Cell Destruction (l)
23	DRIVE	-	Not Used
24	SO2ART	C	O_2 Saturation in Arteries (%)
25	SO2VEN	C	O_2 Saturation in Veins (%)
26	PO2VEN	C	Partial Pressure of O_2 in the Veins (mm Hg)

C = Computed values

No.	Mnemonic	Initial Value	Definition
27	MO2TIS	20.0	Metabolic Tissue Rate (ml O_2 min)
28	P	22.0	Red Cell Production (ml/day)
29	VO2TIS	320.0	Volume of O_2 in Tissue (ml)
30	MCHC	3.75	Mean Corpuscular Hq conc. (gm/l)
31	CHBO2	1.34	Carrying capacity of hemoglobin (ml O_2/gm Hg)
32	RK	C	Diffusion Constant
33	D	22.0	Red Cell Destruction (ml/day)
34	DATA	0.0	Internal switch
35	RCVL	0.0	Red Cell Volume labeled (liters)
36	RCVLO	0.0	Initial Dose labeled Red Cell Volume Change (liter)
37	OPT	0.0	Internal switch (not used)
38	X1	3.0	Values of parameters during optimization Var. 1
39	X2	9.5485 E-	Values of parameters during optimization Var. 2
40	Z	5760.	Red Cell Production Delay Time Const. (min.)
41	P50	26.73	Partial pressure O_2 @ 50% saturation (mm Hg)
42	DPG	37.0	Dummy variable for P_{50} shift due to DPG
43	G1	3.0	Sensitivity or gain of erythropoietin releasing system to tissue pO_2
44	G2	2.0	Sensitivity or gain of bone marrow to plasma erythropoietin conc.
45	PO	0.0	Basal red cell production rate (normalized)
46	P1	1.0	Control value of RC Prod. rate (normal operating point) (normalized)
47	EHL	720.0	Erythropoietin half-life (min.)

C = Computed Values

APPENDIX II (Continued)

No.	Mnemonic	Initial Value	Definition
48	ERYO	1.0	Initial value of E_p (normalized)
49	EPO	20.09	Intercept (changes normal operating point)
50	ENIF	0.0	Erythropoietin infusion (x normal vol.)
51	FCELL	1.0	Ratio of peripheral HCT to whole-body HCT
52	DELTI	0.2	Parameter, optimization constant
53	DELTII	1.0 E-06	" " "
54	EPSI	.01	Not used
55	EPSII	10 E-08	Not used
56	DUM4	50	Not used
57	DK		Not used
58	PO2N	1.	Tissue pO_2 (normalized)
59	EP	1.	Erythropoietin production (normalized)
60	ED	1.	Erythropoietin Destruction normalized)
61	ERY	1.	Erythropoietin Concentration (normalized)
62	RCPN	1.	Gain of erythropoietin on red cell production (normalized)
63	RCP	.0000138	Red cell production (l/min)
64	RCPX	C	Red cell production with time delay(l/min)
65	PRODX	C	Red cell production with time delay (ml/day)
66	PRODZ	-	Not used
67	RNVAR	150.	No variables input/output
68	FLAG	0.	Internal switch (RCM data)
69	EXRCM	C	Experimental red cell mass (liters)

C = Computed Values

```
DBE-603432*IPFS(C).REDCELL
C**** PROGRAM FOR RED BLOOD CELL VOLUME CONTROL
      COMMON /OUTP/NAME(150),IOUT(9),OUTP(9)
      COMMON /INTEG/MODE,ISTEP,IRMAX,NVAR
      COMMON /ERYD/T,TMAX,TPNT,H,BF,PV,RKC,EGAIN,PO2DMD,RCVD,VO2D,
     * BHOTIS,ACM,PO2ART,CO2TIS,PO2TIS,STEP,BV,
     * RCV,HCT,PROD,RCD,DRIVE,SO2ART,SO2VEN,
     & PO2VEN,MO2TIS,P,VO2TIS,MCHC,CHBO2,RK,D,DATA,
     & PCVL,RCVLD,OPT,X1,X2,Z,P50,DPG,
     & G1,G2,PO,P1,EHL,ERYO,EPO,DINF,FCELL,
     & DELTI,DELTII,EPSI,EPSII,DUM3,DK,
     * PO2N,EP,LD,ERY,RCPN,RCP,RCPZ,PRODX,PRODZ,RNVAR,DUMMY(63)
      COMMON/PLTBUF/NBUF,XBUF(181),YBUF(181,8),NW(8),KSTOPP,IS
      REAL MO2TIS,MCHC
      COMMON/EXDATA/EXPV,EXRCM,EXHCT
      COMMON /EDATA/HCTDAT(60),PVDATA(60),RCMDAT(60)
      DATA KY,NEW,MORE,ISTOP,ISA/1HN,3HNEW,4HMORE,4HSTOP,2HSA/
C**** INPUT
      GO TO 10
    5 IS = IS + 1
   10 ISTEP=0
      NBUF=1
      CALL NPUT
      T=0.0
      TPT=0.0
      GO TO 120
C**** TIME INCREMENT
  100 CONTINUE
      T = T + H
      ISTEP=ISTEP+1
  120 CONTINUE
      IF(DATA .LE. 0.) GO TO 125
C**** INTERPOLATE PLASMA VOLUME DATA
      PVI=PV
      TD=T/1440.
      DO 62 I=1,60,2
      IF(TD .LE. PVDATA(I+2) .AND. TD .GE. PVDATA(I)) GO TO 64
   62 CONTINUE
   64 PV = (PVDATA(I+3) - PVDATA(I+1))*(TD - PVDATA(I))/
     *     (PVDATA(I+2) - PVDATA(I)) + PVDATA(I+1)
C     WRITE(6,688)ISTEP,PVI,PV
C 688 FORMAT(1H ,I5,2X,2F10.3)
  125 CONTINUE
C
C****HERE FOR JSC/BAYLOR BED REST SIMULATION
      IF(MODE .NE. 2) GO TO 110
C**** INTERPOLATE HCT DATA
      DO 80 I=1,60,2
      IF(TD .LE. HCTDAT(I+2) .AND. TD .GE. HCTDAT(I)) GO TO 82
   80 CONTINUE
   82 PHCT = (HCTDAT(I+3) - HCTDAT(I+1))*(TD - HCTDAT(I))/
     *     (HCTDAT(I+2) - HCTDAT(I)) + HCTDAT(I+1)
      HCT=FCELL*PHCT
C**** INTERPOLATE RCM DATA
      DO 90 I=1,60,2
      IF(TD .LE. RCMDAT(I+2) .AND. TD .GE. RCMDAT(I)) GO TO 92
   90 CONTINUE
```

```
   92 DATRCM = (RCMDAT(I+3) - RCMDAT(I+1))*(TD - RCMDAT(I))/
     *     (RCMDAT(I+2) - RCMDAT(I)) + RCMDAT(I+1)
  110 CONTINUE
C
C**** COMPUTE TISSUE OXYGEN PARTIAL PRESSURE
      CALL BLOOD
C**** COMPUTE RED BLOOD CELL VOLUME
      CALL TISSUE
      IF(OPT .EQ. 1.0) CALL OPFUNC(T,H,RCV,HCT,FMIN)
C**** TEST FOR TIME LIMIT
      IF (T.GT.TMAX) GO TO 130
      IF (T.LT.TPT) GO TO 100
      IF(ISTEP .EQ. 0 ) CALL INPUT2
C**** OUTPUT
  130 IF(OPT.EQ.0.0)CALL OUTPUT
      TPT=TPT+TPNT
      IF (T.LT.TMAX) GO TO 100
      CALL PAGE3
      KSTOPP=1
      WRITE (6,140)
  140 FORMAT ('0DO YOU WISH TO PLOT BUFFERED DATA?  (Y/N CR)')
      READ (5,200) KK
      IF (KK.NE.KY) CALL PLOT
  145 IF(OPT .EQ. 0.0) GO TO 160
C     WRITE(6,170) PV,RCV,FMIN,T
  170 FORMAT(' PV=',F10.3,5X,'RCV=',F10.3,5X,'FMIN=',F10.5,F10.2)
      CALL SEARCH(FMIN,X1,X2,OPT)
C     WRITE(6,170)X1,RCV,FMIN,T
      GO TO 10
  160 WRITE (6,150)
  150 FORMAT(/'0WISH TO CONTINUE? (ENTER =NEW=,=MORE=,OR =STOP=, )')
C 150 FORMAT(/'0WISH TO CONTINUE?',
C    *  ' KEY IN: =NEW= - BEGINS NEW RUN'/26X,'=MORE= - ',
C    * 'CONTINUES THIS RUN'/26X,'=STOP= - EXITS FROM SIMULATION'/)
      READ (5,200) IRS
      IF (IRS.EQ.ISTOP) CALL EXIT
      IF (IRS.EQ.NEW) GO TO 10
      IF(IRS.EQ.ISA) GO TO 5
      IF (IRS.NE.MORE) GO TO 160
      TPT=TPT-TPNT
      CALL INPUT2
      TPT=TPT+TPNT
      GO TO 100
  200 FORMAT(1A4)
      END
```

@PRT,S NPUT

```
D86-003432*TPFS(0).NPUT
          SUBROUTINE NPUT
          DIMENSION ERYD(150)
          COMMON /OUTP/NAME(150),IOUT(9),OUTP(9)
          COMMON /INTEG/MODE,ISTEP,IRMAX,NVAR
          COMMON /ERYD/T,TMAX,TPNT,H,BF,PV,RKC,EGAIN,PO2DMD,RCVO,VO2D,
     *    BMOTIS,AOM,PO2ART,CO2TIS,PO2TIS,STEP,BV,
     *    RCV,HCT,PROD,RCD,DRIVE,SO2ART,SO2VEN,
     &    PO2VEN,MO2TIS,D,VO2TIS,MCHC,CHBO2,RK,P,DATA,
     &    RCVL,RCVLO,OPT,X1,X2,Z,P50,DPG,
     &    G1,G2,P0,P1,EHL,ERYO,EPO,EINF,FCELL,
     &    DELTI,DELTII,EPSI,EPSII,DUM3,DK,
     *    PO2N,EP,ED,ERY,RCPN,RCP,RCP2,PRODX,PRODL,RNVAR,DUMMY(83)
          REAL MO2TIS,MCHC
          DATA MODE,ISTEP,IRMAX,NVAR/1,0,50,150/
          EQUIVALENCE (ERYD(1),T)
C         NAMELIST IN/TMAX,TPNT,H,RCVO,RCVLO,PV,BF,AOM,MCHC,
C    *               CHBO2,RKC,MODE,DATA,PO2ART,OPT,Z,EGAIN,P50,
C    *               G1,G2,P0,P1,EHL,EPO,ERYO,EINF,FCELL/
          NAMELIST MIN/DELTI,DELTII,EPSI,EPSII,IRMAX,X1,X2/
C         DATA OPT,IRMAX,DELTI,DELTII,EPSI,EPSII,X1,X2/
C    *    0.0,50,.2,10.E-05,.01,10.E-07,3.0,9.5485E-06/
          DATA ISTOP,ISAME,IBLNK,KY,IEND/'STOP','SAME','      ','Y','END'/
          DATA IOUT/1,19,18,20,16,6,28,33,61/
C**** INITIAL DATA
          IF(OPT .NE. 1.0) GO TO 5
C         TMAX=0.0
C         TPNT=0.0
        5 CONTINUE
   66     CALL ERTRAN(6,'@ADD .BDAT . ')
  200     FORMAT(I3,4X,A6,2X,F15.6)
    6      READ(5,200,ERR=201,END=202)I,NAME(I),ERYD(I)
          NC=NC+1
          IF(I.GE.NVAR)GO TO 202
C         WRITE(6,988)NC,I,NAME(I),ERYD(I)
C 988     FORMAT(1H ,I5,I5,2X,A6,2X,F15.6)
          GO TO 6
  201     WRITE(6,203)I
  203     FORMAT(' ERROR READING INPUT FILE ,VAR NO.',I3)
          GO TO 66
  202     WRITE(6,204)NC
  204     FORMAT(1H ,I5,' CARDS READ AS INPUT')
C
C           COMPUTE INITIAL VALUES FOR PO2ART,PO2TIS,QO2TIS & KR
C
          PO2TIS = 625. * VO2D
          QO2TIS = BMOTIS
          CALL GETSAT(SO2ART,PO2ART,DPG)
          HCT = RCVO/(RCVO + PV)*100.
          SO2VEN = SO2ART - BMOTIS/(BF*HCT*MCHC*CHBO2)
          CALL GETPO2(SO2VEN,PO2VEN,DPG)
          RK = QO2TIS*(PO2TIS**3.)/(PO2VEN-PO2TIS)
          EPO=EXP(G1)
          EPOX=EPO
          RETURN
          ENTRY INPUT2
          NLOC=1
```

```
  505 IOUT(NNLOC)=1
      WRITE(6,955)NNLOC,NAME(I)
  955  FORMAT(' LOC=',I1,' = ,NAME= ',A6)
      IF(NLOC.GT.9)GO TO 667
      GO TO 666
  667  CONTINUE
      CALL GETSAT(XS,PO2ART,DPG)
C     WRITE(6,55) XS
C  55 FORMAT('       SO2ART =',F5.2)
      DPG=(PSD + 30.62)/1.55
      XD=PSD-26.73
      IF(DPG .NE. 37.) WRITE(6,65) XD
   65 FORMAT(' PSD SHIFT =',F5.2)
      IF(EPO .NE. EPOX) GO TO 74
      EPO=EXP(G1)
      EPOX=EPO
C  74 WRITE(6,75) EPO
C  75 FORMAT('            EPO =',F5.2)
   74  CONTINUE
   50 CONTINUE
      IF(OPT .EQ. 0.) GO TO 90
      WRITE(6,MIN)
      WRITE(6,60)
   60 FORMAT(//' CHANGE DELT,EPS,OR X USING NAMELIST $MIN')
      READ(5,MIN)
   70 PV = X1
      EGAIN = X2
      WRITE(6,120) PV,X1,ISTEP,T
  120 FORMAT(' PV,X1,ISTEP,T=',4F10.3)
   90 IF (TMAX.LT.1440.) TMAX=TMAX+1440.
      IF (TPNT.LT.70.) TPNT=TPNT+1440.
      RETURN
      END
```

@PRT,S TISU

```
      IF(OPT .EQ. 1.0) GO TO 70
      IF (ISTEP.EQ.0) WRITE (6,30)
   30 FORMAT(///15X,'**MODEL FOR REGULATION',
     * ' OF ERYTHROPOIESIS**',/)
      IF (ISTEP.EQ.0) GO TO 45
C     TMAX=TMAX/1440.
C     TPNT=TPNT/1440.
C     WRITE(6,IN)
C     TMAX=TMAX*1440.
C     TPNT=TPNT*1440.
   19 WRITE (6,20)
   20 FORMAT(/' TMAX MUST BE INCREASED'/  ' ALL PREVIOUS DATA CHANGES',
     * ' WILL REMAIN SAME UNLESS CHANGED NOW')
   45 WRITE(6,944)
  944  FORMAT(' EXPERIMENTAL DATA WANTED? (Y/N)')
      READ(5,943)KN
  943  FORMAT(A1)
      IF(KN.NE.KY)GO TO 942
      CALL XPER
  942  CONTINUE
      WRITE(6,994)
  994 FORMAT(' NO. DAYS WANTED,PRINT STEP')
   78 READ(5,996)TM,TPNT
  996  FORMAT()
C     IF(TM.LT.TMAX)GO TO 19
      TMAX=TM+TMAX
      WRITE(6,993)
  993  FORMAT(' INPUT WANTED CHANGED, END'/,
     &' NAME  VALUE',/'------ -------------')
  500  READ(5,999)NMEM,RDATA
  999  FORMAT(A6,F16.8)
      IF(NMEM.EQ.IEND)GO TO 888
      IF(NMEM.EQ.IBLNK)GO TO 888
      DO 501 I=1,NVAR
  501  IF(NMEM.EQ.NAME(I))GO TO 502
      WRITE(6,998)NMEM
  998  FORMAT(' NAME ',A6,' NOT RECOGNIZED TRY AGAIN')
      GOTO 500
  502  WRITE(6,997)I,NAME(I),RDATA,ERYD(I)
  997  FORMAT(' ',I4,2X,A6,' = ',G10.5,'CHANGED FROM',G10.5)
      ERYD(I)=RDATA
      GO TO 500
  888  WRITE(6,992)
  992 FORMAT(' OUTPUT WANTED OR SAME,STOP'/,
     &' NAME ',/' ------',)
  503  READ(5,995)NMEM,LOC
  995  FORMAT(A6,1X,I1)
      IF(NMEM.EQ.ISTOP)GO TO 887
      IF(NMEM.EQ.ISAME)GO TO 887
      IF(NMEM.EQ.IBLNK)GO TO 867
      NLOC=NLOC+1
      NNLOC=NLOC
      IF(LOC.GE.1.AND.LOC.LE.9)NNLOC=LOC
      DO 504 I=1,NVAR
  504  IF(NMEM.EQ.NAME(I))GO TO 505
      WRITE(6,998)NMEM
      GO TO 503
```

```
DB6-GD3432*TPFS(D).TISU
              SUBROUTINE TISSUE
              REAL INTGRL,MO2TIS,MCHC
              COMMON /ERYD/T,TMAX,TPNT,H,BF,PV,RKC,EGAIN,PO2DMD,RCVD,VO2O,
             * BMOTIS,AOM,PO2ART,QO2TIS,PO2TIS,STEP,BV,
             * RCV,HCT,PROD,RCD,DRIVE,SO2ART,SO2VEN,
             & PO2VEN,MO2TIS,DUM1,VO2TIS,MCHC,CHBO2,RK,DUM2,DATA,
             & RCVL,RCVLO,OPT,X1,X2,Z,PSO,DPG,
             & G1,G2,PO,P1,EHL,ERYO,EPO,EINF,FCELL,
             6 DELTI,DELTII,EPSI,EPSII,DUM3,DK,
             * PO2N,EP,ED,ERY,RCPN,RCP,RCPZ,PRODX,PRODZ,RNVAR,DUMMY(83)
              COMMON/TISS/COXART,QO2VEN,RDIFO2,VO2DOT,QO2ART
              NAMELIST SP/PO2ART,SO2ART,COXART,QO2VEN,SO2VEN,
             *  PO2VEN,RDIFO2,QO2TIS,MO2TIS,VO2DOT,VO2TIS,PO2TIS/
               CALL GETSAT(SO2ART,PO2ART,DPG)
              COXART=SO2ART*HCT*MCHC*CHBO2
              QO2ART=BF*COXART
              QO2VEN=QO2ART-QO2TIS
              SO2VEN=QO2VEN/(BF*HCT*MCHC*CHBO2)
              CALL GETPO2(SO2VEN,PO2VEN,DPG)
               RDIFO2=8000.
C             RDIFO2=PO2TIS**3.
              IF (RDIFO2.LT.50.) RDIFO2=50.
              QO2TIS=(PO2VEN-PO2TIS)*RK/RDIFO2
              MO2TIS=BMOTIS*AOM
              VO2DOT=QO2TIS-MO2TIS
C             IF(ISTEP .EQ. 0) VO2DOT = 0.0
              VO2O= 320.
              VO2TIS=INTGRL(T,H,VO2DOT,VO2TIS,VO2O)
              PO2TIS=.0625*VO2TIS
C             WRITE(6,SP)
              RETURN
              END

@PRT,S BLUD
```

DB6-003432*TPFS(0).BLOOD

```
      SUBROUTINE BLOOD
      REAL INTGRL,MO2TIS,MCHC
      COMMON /INTEG/MODE,ISTEP,IRMAX,NVAR
      COMMON /ERYD/T,TMAX,TPNT,H,BF,PV,RKC,EGAIN,PO2DMD,RCVD,VO2D,
     * BMOTIS,AOR,PO2ART,CO2TIS,PO2TIS,STEP,BV,
     * RCV,HCT,PROD,RCD,DRIVE,SO2ART,SO2VEN,
     & PO2VEN,MO2TIS,DUM1,VO2TIS,MCHC,CHBO2,RK,DUM2,DATA,
     & RCVL,RCVLD,OPT,X1,X2,Z,PSJ,DPG,
     & G1,G2,P0,P1,EHL,ERYO,EPO,EINF,FCELL,
     6 DELTI,DELTII,EPSI,EPSII,DUM3,DK,
     * PO2N,EP,ED,ERY,RCPN,RCP,RCPZ,PRODX,PRODZ,RNVAR,DUMMY(63)
C     NAMELIST OUT/T,PO2N,EP,ED,ERY,RCPN,RCP,RCPZ,PRODZ,PRODX/
C****INITIALIZATION
      IF(ISTEP .GT. 0) GO TO 10
      EDOT=0.0
      RCVDOT=0.0
      RDOTL=0.0
      RCPO=RCVD*RKC
      RCPZ=RCPO
   10 CONTINUE
C     NORMALIZED TISSUE PO2
      PO2N=PO2TIS/20.0
C     ERYTHROPOIETIN PRODUCTION
      EP = EPO*EXP(-G1*PO2N)
C     ERYTHROPOIETIN CONCENTRATION
      EDOT = (EP - ERY)*0.693/EHL
      ERY = INTGRL(T,H,EDOT,ERY,ERYO)
      IF(ERY .LE. 0.) ERY = 0.0
C     INFUSE ERY DOSE  (PULSE)
      IF(EINF .EQ. 0.) GO TO 50
      ERY = ERY + EINF
      EINF=0.
   50 CONTINUE
C     RED CELL PRODUCTION
      ES=EXP((5.- P1)/G2)
      IF(ERY .GT. ES) GO TO 200
      IF(ERY .GT. 1.0) GO TO 100
      Z1 = G2/(P1-P0)
      RCPN = P0 + (P1-P0)*ERY**Z1
      GO TO 300
  100 RCPN = G2*ALOG(ERY) + P1
      GO TO 300
  200 Z2 = G2/EXP((5.-P1)/G2)
      Z3 = 6. - EXP(G2)
      RCPN = 6. + (Z3-6.)*EXP(-Z2*ERY)
  300 IF(RCPN .LT. 0.) RCPN = 0.0
      IF(RCPN .GT. 6.) RCPN = 6.0
C     TIME DELAY FOR RBC PRODUCTION
      RCP = RCPN*RCPO
C     XX=EGAIN*(Z**(1000*1440*(RCP-RCPZ)))
      RCPZ = RCPZ + (RCP-RCPZ)/Z
C     RCPZO = RCPZO + (RCP-RCPZO)/Z
C     RCPZ=RCPZO + (RCP-RCPZO)/EGAIN
      PRODX=RCPZ*1000.*1440.
      MX = ISTEP/60.
      TX = ISTEP/60. - MX
```

ORIGINAL PAGE IS OF POOR QUALITY

```
C      CALL SARCM
       IF (NBUF.GT.1) GO TO 225
       XBUF(1)=0.
C      YBUF(NBUF,1)=RCV
C      YBUF(NBUF,2)=HCT
C      YBUF(NBUF,3)=BV
C      YBUF(NBUF,4)=ERY
C      YBUF(NBUF,5)=PV
C      YBUF(NBUF,6)=P
C      YBUF(NBUF,7)=D
C      YBUF(NBUF,8)=EP
C      YBUF(NBUF,7)=EXRCM
C      YBUF(NBUF,8)=EXPV
       DO 70 NX=1,7
   70  YBUF(NBUF,NX)=OUTP(NX+1)
       NBUF=NBUF+1
       XBUF(NBUF)=TPNT/1440. - TPNT/1440./1.
       GO TO 230
  225  CONTINUE
       IF (T/1440..LT.PLTIME) GO TO 300
       PLTIME=PLTIME+TMAX/1440./180.
       NBUF=NBUF+1
       IF (NBUF.GT.181) NBUF=181
       XBUF(NBUF)=T/1440.
C 230  YBUF(NBUF,1)=RCV
C      YBUF(NBUF,2)=HCT
C      YBUF(NBUF,3)=BV
C      YBUF(NBUF,4)=ERY
C      YBUF(NBUF,5)=PV
C      YBUF(NBUF,6)=P
CC     YBUF(NBUF,7)=D
CC     YBUF(NBUF,8)=EP
C      YBUF(NBUF,7)=EXRCM
C      YBUF(NBUF,8)=EXPV
  230  DO 90 NX=1,7
   90  YBUF(NBUF,NX)=OUTP(NX+1)
       IF (KPLT.GT.0) CALL PLOT
  300  IF (KPLT.GT.0) GO TO 310
C      WRITE (6,10) TD,RCV,BV,HCT,P,D,PO2TIS,PO2VEN
C      WRITE(6,10) TD,PO2TIS,EP,ED,ERY,P,PRODZ,RCV
C   10 FORMAT (1X,F6.2,2F9.3,5F9.2)
C      WRITE(6,30) TD,RCV,BV,HCT,PO2TIS,PV,ERY,P,D
C   30 FORMAT(F6.2,2F9.3,F8.2,F9.2,F6.3,F7.2,2F6.2)
       DO 11 I=1,9
       NOUT=IOUT(I)
   11  OUTP(I)=ERYD(NOUT)
       IF(IOUT(1).EQ.1)OUTP(1)=T/1440.
       WRITE(6,400)(OUTP(I),I=1,9)
  400   FORMAT(1H ,8(F8.2),F7.2)
C      IF(IS .LT. 1) GO TO 310
C      WRITE(6,500) TTD, JJJ,SCR,SCP,SCD
C 500  FORMAT(1X,F6.2,I5,5X,'SCR=',F10.4,5X,'SCP=',F10.4,
C     * 5X,'SCD=',F10.4/)
C       WRITE(6,OUT)
C      WRITE(6,SP)
  310  RETURN
       END
```

DB6-C03432*TPF$(C).OUTPT

```
      SUBROUTINE OUTPUT
      DIMENSION ERYD(150)
      COMMON /OUTP/NAME(150),IOUT(9),OUTP(9),NOUTP(9)
      COMMON /INTEG/MODE,ISTEP,IRMAX,NVAR
      COMMON /ERYD/T,TMAX,TPNT,H,BF,PV,RKC,EGAIN,PO2DMD,RCVO,VO2D,
     * SMOTIS,AOM,PO2ART,QO2TIS,PO2TIS,STEP,BV,
     * RCV,HCT,PROD,RCD,DRIVE,SO2ART,SO2VEN,
     & PO2VEN,MO2TIS,D,VO2TIS,MCHC,CHBO2,RK,P,DATA,
     & RCVL,RCVLD,DPT,X1,X2,Z,PSD,DPG,
     & G1,G2,PO,P1,EHL,ERYO,EPO,EINF,FCELL,
     6 DELT1,DELTII,EPSI,EPSII,DUM3,DK,
     * PO2N,EP,ED,ERY,RCPN,RCP,RCPZ,PRODX,PRODZ,RNVAR,DUMMY(63)
      REAL MO2TIS,MCHC
      EQUIVALENCE(ERYD(1),T)
      COMMON/PLTBUF/NBUF,XBUF(181),YBUF(181,8),NW(8),KSTOPP,IS
      COMMON/TISS/COXART,CO2VEN,RDIFO2,VO2DOT,CO2ART
      COMMON/SA/SCH,SCP,SCD,JJJ,TTD
      COMMON/EXDATA/EXPV,EXRCM,EXHCT
C     NAMELIST OUT/T,PO2N,EP,ED,ERY,RCPN,RCP,RCPZ,PRODZ,PRODX/
C     NAMELIST SP/PO2ART,ISTEP,COXART,CO2VEN,SO2VEN,
C    +  PO2VEN,RDIFO2,CO2TIS,MO2TIS,VO2DOT,VO2TIS,PO2TIS/
      DATA KY,IDAY,IP,ID/1HN,4HDAYS,1HP,1HD/
C     DATA NW/'   RCM','   HCT','PO2TIS','   ERY',
C    *  '    PV','   RCP','   RCD','    EP'/
C     DATA NW/'   RCM','   HCT','    BV','   ERY',
C    *        '    PV','   RCP','JSCRCM','JSCPV'/
C     WRITE(6,SP)
      IF (ISTEP.GT.0) GO TO 9
      WRITE (6,7)
    7 FORMAT('ODO YOU WANT GRAPHIC INSTEAD OF TABULAR OUTPUT? (Y/N)')
      READ (5,20) K
   20 FORMAT(1A1)
      IF (K.NE.KY) KPLT=1
      DO 1 I=2,9
      NOUT=IOUT(I)
    1 NW(I-1)=NAME(NOUT)
C     KPLT=0  @  TAKE OUT PLOT
      IF(KPLT .GT. 0) GO TO 8
C     WRITE (6,5)
      DO 511 I=1,9
      NOUT=IOUT(I)
  511  NOUTP(I)=NAME(NOUT)
      IF(IOUT(1).EQ.1)NOUTP(1)=IDAY
      WRITE(6,512)(NOUTP(I),I=1,9)
  512  FORMAT(1H ,4X,8(A6,2X),A6)
C   5 FORMAT(//' TIME      RCM      BV       HCT      PO2TIS',
C    *'     PV     ERY     RCP     RCD')
C   5 FORMAT(//'   TIME    PO2TIS     EP        ED       ERY',
C    *'        P          PRODZ       RCV')
C     WRITE(6,6)
C   6 FORMAT( ' DAYS   LITERS    LITERS              MMHG ',
C    * 'LITERS            ML/DAY  ML/DAY '/)
    8 PLTIME=TMAX/1440./180.
    9 TD=T/1440.
      P=RCPZ*1000.*1440.
      D=RCD*1000.*1440.
```

```
C       IF(TX .EQ. 0.) WRITE(6,OUT)
C
C       DRIVE=PO2DMD-PO2TIS
C       PRO=DRIVE*EGAIN
C       PROD=PROD+(PRO-PROD)/Z
C       IF(ISTEP .EQ. 0) PRODD = PROD
C       IF(PROD .GT. 6.*PRODD) PROD = PRODD*6.0
CC      IF(PROD .LT. 0.5*PRODD) PROD = PRODD*0.5
C       IF(PROD .LT. 0.0) PROD = 0.0
C       PRODZ=PROD*1000.*1440.
C
        RCVDOT=RCPZ - RCD
        RCV=INTGRL(T,H,RCVDOT,RCV,RCVD)
        IF(RCVLO .NE. 0.)RCV=RCV+RCVLO
        RCVLO=0.
        RCD=RCV*RKC
C        DISAPPEARANCE OF INFUSED LABELED RED CELLS
        RDOTL = -DSTRTL
        RCVL = INTGRL(T,H,RDOTL,RCVL,RCVLO)
        DSTRTL = RCVL*RKC
C
        IF(MODE .EQ. 2) GO TO 400
        HCT= 100.*(RCV+RCVL)/BV
        GO TO 500
    400 PV= (RCV+RCVL)*(100.-HCT)/HCT
    500 BV = PV+RCV+RCVL
        RETURN
        END
```

@PRT,S OUTPT

```
DB6-003432*THERM(1).INTGRL
          REAL FUNCTION INTGRL(T,H,XDOT,Y,YD)
          Y=Y+H*XDOT
          IF(T .LE. H) Y=YD
          INTGRL=Y
          RETURN
          END

@PRT,S THERM.GETSP
```

```
DBS-CD3432*THERM(1).GETSP
      SUBROUTINE GETSAT(SAT,PO2,TEMP)
      O2SF(XX)=51.87074+XX*(129.8325+XX*(6.828369-XX*(223.7881*
     & XX*(27.953-XX*(258.5009+XX*(21.84175-XX*119.2322))))))
C     TEMP=37.
      IF(TEMP .EQ. 0.) TEMP=37.
      PH=7.4
      BE=0.
      PO2C=PO2*10**(0.024*(37.-TEMP)-0.48*(7.4-PH)-0.0013*BE)
      X=(PO2C-27.5)/(PO2C+27.5)
      SAT=O2SF(X)/100.0
      RETURN
C****
      ENTRY GETPO2(SAT,PO2,TEMP)
      SAT = SAT*100.0
      DPO2=99.
      PO2=100.
    1 X=(PO2-27.5)/(PO2+27.5)
      OSAT=O2SF(X)
      IF (DPO2.LT.0.01) GO TO 4
      IF (OSAT.GT.SAT) GO TO 2
      PO2=PO2+DPO2
      GO TO 3
    2 PO2=PO2-DPO2
    3 DPO2=DPO2/2.
      GO TO 1
    4 CONTINUE
      PO2=PO2*10**(0.024*(TEMP-37.)-0.48*(PH-7.4)+0.0013*BE)
      SAT = SAT/100.0
      RETURN
      END

@PRT,S THERM.SEARCH
```

```
D86-C03432*TPFS(0).PLOTN
      SUBROUTINE PLOT
      COMMON/ERYD/T,TMAX,DUMMY(148)
      COMMON/PLTBUF/IPLTPT,TLOTBF(181),PLOTBF(181,8),ALPHA(8),KSTOPP,IS
     & ,PUL(2)
      DIMENSION HEAD(6)
      DATA HEAD/'RED BLOOD CELL VOLUME CONTROL          '/
      DIMENSION TSTEPX(4),TSTALP(4)
      DATA TSTEPX/1.,1.,60.,1440./
      DATA TSTALP/'DAYS','MINS','HOUR','DAYS'/
      DIMENSION IIDAS(8,2),PPARS(3,3)
      DIMENSION XNU(5)
      DATA ISA/'S    '/,IN/'N    '/,IY/'Y    '/,IPLL/'PLOT'/
C****
      DATA PPARS/1.,2.,3.,4.,5.,5.,6.,6.,
     &   3.,50.,25.,70.,4.,4.,40.,40.,
     &   1.,30.,15.,50.,0.,0.,0.,0./
C****
      DATA IFIRST,KSTOPP,NOP/0,0,6/
      IF (IFIRST.EQ.0) CALL INITT(300)
      IFIRST=1
      K=8
      IEXECI=IPLL
      IS = IPLTPT - 1
      IF(IPLTPT .LE. 2) GO TO 1
      IF(IEXECI .EQ. IPLL .AND. KSTOPP .EQ. 0)
     1 GO TO 28
      IF(IEXECI .EQ. IPLL .AND. KSTOPP .EQ. 1)
     1 GO TO 120
    1 IS = 1
   11 WRITE(6,2)
    2 FORMAT(9X,' GRAPHIC OUTPUT(Y,N,S),TIME INTERVALS,STARTX,'
     & ,'STOPX,(A2,3F5.0)..')
    4 READ(5,3,ERR=4) I,TSPLIT,STARTX,STOPX
    3 FORMAT(A2,3F5.0)
      IF (STOPX.LT.1.) STOPX=TMAX/1440.
      IF (STARTX.LT.1.) STARTX=TLOTBF(1)
      RUNSTP=STOPX-STARTX
      ITSPT = TSPLIT
      IF(I .EQ. IN) RETURN
      IF(I .EQ. ISA) GO TO 10
      IF(I .NE. IY) GO TO 11
      IF(TSPLIT .LT. 3. .OR. TSPLIT .GT. 5.) GO TO 11
C     HERE TO BUILD PLOT PARAMETERS.
      NOP = 0
      DO 20 I = 1,K
   17 WRITE(6,5) ALPHA(I)
    5 FORMAT(' ',A6,13X,'Y SCALE    (A4,8X,F4.0,2F6.0)'/
     1 ' PLOT(Y,N,S) LOC HIGH  LOW     ...')
    7 READ(5,6,ERR=7) II,XP1,XP2,XP3
    6 FORMAT(A4,8X,F4.0,2F6.0)
      IF(II .EQ. IY) GO TO 18
      IF(II .EQ. ISA) GO TO 19
      IF(II .NE. IN) GO TO 17
      PPARS(I,1) = 0.
      GO TO 20
   18 IF(XP1 .LE. 0.) GO TO 17
```

```
      IF(IFIX(XP1) .GT. 6) GO TO 17
      IF(XP3 .GE. XP2) GO TO 17
      PPARS(I,1) = XP1
      PPARS(I,2) = XP2
      PPARS(I,3) = XP3
   19 IF(IFIX(PPARS(I,1)) .GT. NOP) NOP = PPARS(I,1)
      IF(PPARS(I,1) .LT. 1.) GO TO 17
   20 CONTINUE
C   BUILD WHOLE PAGE GRAPH.
   10 CALL NEWPAG
      CALL MOVABS(300,790)
      CALL DMPBUF
C     WRITE (6,21) HEAD
C  21 FORMAT(25X,6A6)
      CALL MOVABS(3,100)
      CALL DRWABS(1000,100)
      CALL DRWABS(1000,750)
      CALL DRWABS(3,750)
      CALL DRWABS(3,100)
      CALL MOVABS(300,750)
      CALL DRWABS(300,100)
      CALL DMPBUF
      I1 = TTSPT - 1.
      I2 = 300
      I3 = 700 / (I1 + 1)
      DO 25 I = 1,I1
      I2 = I2 + I3
      CALL MOVABS(I2,100)
      CALL DRWABS(I2,750)
   25 CONTINUE
      CALL DMPBUF
C   DRAW DIVISIONS FOR DIFFERENT GRAPHS.
      I3Y = 650 / NOP
      I4Y = I3Y / 2
      I1 = NOP - 1
      I2 = 100
      IF(I1 .LT. 1) GO TO 280
      DO 26 I = 1,I1
      I4 = I2 + I4Y
      CALL MOVABS(300,I4)
      CALL DRWABS(305,I4)
      CALL MOVABS(995,I4)
      CALL DRWABS(1000,I4)
      I2 = I2 + I3Y
      CALL MOVABS(3,I2)
      CALL DRWABS(1000,I2)
      CALL DMPBUF
   26 CONTINUE
  280 I4 = I2 + I4Y
      CALL MOVABS(300,I4)
      CALL DRWABS(305,I4)
      CALL MOVABS(995,I4)
      CALL DRWABS(1000,I4)
      CALL DMPBUF
C   ADD ALPHA
      I1 = 750
      IDUP = 1
```


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OF P...

```
      CALL VWINDO(0.,1023.,0.,780.)
      CALL SWINDO(0,1023,0,780)
      DO 70 I = 1,NOP
      I11 = I1
      I22 = I1 - I3Y + 30
      ID = 0
      DO 60 J = 1,K
      IF(IFIX(PPARS(J,1)) .NE. I) GO TO 60
      CALL MOVABS(0,I11)
      CALL ANMODE
      CALL DMPBUF
      WRITE(6,55) ALPHA(J),PPARS(J,2)
   55 FORMAT(' ',6X,A6,F8.2)
      Y1 = I11 - 11.
      CALL MOVEA(10.,Y1)
      IF(ID .EQ. 0) GO TO 410
      ID1 = 0
      ID2 = 0
      CALL DSHARC(104.,Y1,ID,ID1,ID2,IDUP)
      GO TO 411
  410 CALL DRAWA(104.,Y1)
  411 CALL MOVABS(0,I22)
      CALL ANMODE
      CALL DMPBUF
      WRITE(6,55) ALPHA(J),PPARS(J,3)
      Y1 = I22 - 13.
      CALL MOVEA(10.,Y1)
      IF(ID .EQ. 0) GO TO 413
      ID1 = 0
      ID2 = 0
      CALL DSHARC(104.,Y1,ID,ID1,ID2,IDUP)
      GO TO 415
  413 CALL DRAWA(104.,Y1)
  415 ID = ID + 1
      I11 = I11 - 21
      I22 = I22 + 21
   60 CONTINUE
      I1 = I1 - I3Y
   70 CONTINUE
      X = (RUNSTP/TTSPT) + .000001
      I = 1
C      IF(X .LT. 1.) I = 1
C      IF(X .GE. 60.) I = 3
C      IF(X .GE. 1440.) I = 4
      X = X / TSTEPX(I)
      IF (STARTX.LT.1.) STARTX=TLOTBF(1)
      X2 = STARTX / TSTEPX(I)
      X1 = X2 + X
      I1 = TTSPT
      DO 75 J = 1,I1
      XNO(J) = X1
      X1 = X1 + X
   75 CONTINUE
      CALL MOVABS(0,100)
      CALL ANMODE
      CALL DMPBUF
      IF(TTSPT .GT. 4.) GO TO 80
```

```
      IF(TTSPT .GT. 3.) GO TO 79
      WRITE(6,93) X2,(XNO(J),J=1,3)
   93 FORMAT(' ',15X,F6.1,11X,F6.1,11X,F6.1,10X,F6.1)
      GO TO 85
   79 WRITE(6,77) X2,(XNO(J),J=1,4)
   77 FORMAT(' ',15X,F6.1,6X,F6.1,7X,F6.1,6X,F6.1,7X,F6.1)
      GO TO 85
   80 WRITE(6,81) X2,(XNO(J),J=1,5)
   81 FORMAT(' ',11X,5(4X,F6.1))
   85 WRITE(6,86) TSTALF(I)
   86 FORMAT(' ',30X,'TIME (',A4,')')
C  INITIALIZE DASH INFORMATION.
      DO 90 J = 1,6
      IIDAS(J,I) = 0
   90 CONTINUE
C     IF(IEXECI .EQ. IPLL) RETURN
C  PLOT VARIABLES...
   28 IL = 750
      IS2 = IS
      I2 = IPLTPT
      DO 40 I = 1,NOP
      IL = IL - I3Y
      IDAS = -1
      IDUP = 1
      DO 30 II = 1,K
      IF(IFIX(PPARS(II,1)) .NE. 1) GO TO 30
      IDAS = IDAS + 1
      X = TLOTBF(I)
      IF (STARTX.GT.0.1) X=STARTX
      XL = RUNSTP
      Y = PPARS(II,3)
      YL = PPARS(II,2) - Y
      CALL WWINDO(X,XL,Y,YL)
      CALL SWINDO(300,700,IL,I3Y)
      X = TLOTBF(IS)
      Y = PLOTBF(IS,II)
      IF(IS .EQ. 1) CALL PLSYM(X,Y,IDUP)
      IF(IEXECI .NE. IPLL) GO TO 97
      IF(Y .LE. PPARS(II,2)) GO TO 105
      IF(PLOTBF(IS2,II) .GE. PPARS(II,2)) GO TO 30
      IF (TLOTBF(II).GT.STOPX) GO TO 30
      YY = PPARS(II,2)
      GO TO 96
  105 IF(Y .GE. PPARS(II,3)) GO TO 97
      IF(PLOTBF(IS2,II) .LT. PPARS(II,3)) GO TO 30
      YY = PPARS(II,3)
   96 CALL MOVEA(X,YY)
      IDUP = IDUP + 1
   97 IDUP = IDUP + 1
      CALL MOVEA(X,Y)
      DO 35 III = IS2,I2
      X = TLOTBF(III)
      Y = PLOTBF(III,II)
      IF(IDAS .GT. 0) GO TO 33
      IDUP = IDUP + 1
      CALL DRAWA(X,Y)
      GO TO 34
```

```
   33 L = IIDAS(II,1)
      N = IIDAS(II,2)
      CALL DSHARC(X,Y,IDAS,L,N,IDUP)
      IIDAS(II,1) = L
      IIDAS(II,2) = N
   34 IF(IDUP .LT. 13 ) GO TO 35
      CALL DMPBUF
      IDUP = 1
   35 CONTINUE
   30 CONTINUE
   40 CALL DMPBUF
      IF(IDUP .GT. 1) CALL DMPBUF
      IF(KSTOPP .EQ. 0) RETURN
  120 CALL PAGE3
      IEXECI = 0
      GO TO 1
      END
```

@PRT,S SARCM
DB6-C03432*TPFS(0).SARCM-SYM NOT FOUND

@PRT,S BDAT

DB6-003432*TPFS(0).DDAT

1	1	T	1.0
2	2	TMAX	1.0
3	3	TPNT	1.0
4	4	K	1.0
5	5	BF	1.2
6	6	PV	3.0
7	7	KKC	.0000076369
8	8	X1	0.0
9	9	PO2DMD	0.0
10	10	RCVO	2.0
11	11	VO2O	0.032
12	12	BMOTIS	20.0
13	13	AUM	1.0
14	14	PO2ART	95.0
15	15	QO2TIS	0.0
16	16	PO2TIS	0.0
17	17	STEP	0.0
18	18	BV	5.0
19	19	RCV	0.0
20	20	HCT	0.0
21	21	PROD	0.0
22	22	RCD	0.0
23	23	DRIVE	0.0
24	24	SO2ART	0.0
25	25	SO2VEN	0.0
26	26	PO2VEN	0.0
27	27	MO2TIS	0.0
28	28	D	1
29	29	VO2TIS	0.0
30	30	MCHC	3.75
31	31	CHBO2	1.34
32	32	RK	0.0
33	33	P	0
34	34	DATA	0.0
35	35	RCVL	0.0
36	36	RCVLO	0.0
37	37	OPT	0.0
38	38	XI	3.0
39	39	X2	.0000095465
40	40	Z	5760.0
41	41	PSO	26.73
42	42	DPG	37.
43	43	G1	3.0
44	44	G2	2.0
45	45	P0	0.0
46	46	P1	1.0
47	47	EHL	720.0
48	48	ERYO	1.0
49	49	EPO	0.0
50	50	ENIF	0.0
51	51	FCELL	1.0
52	52	DELTI	0.2
53	53	DELTII	.0000010
54	54	EPSI	0.01
55	55	EPSII	0.00000001
56	56	IRMAX	50

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57	57	DK	0.0
58	58	POZN	0.0
59	59	LP	0.0
60	60	LO	0.0
61	61	ERY	0.0
62	62	RCPN	0.0
63	63	RCP	0.0
64	64	RCPZ	0.0
65	65	PRODX	0.0
66	66	PRODZ	0.0
67	67	NVAR	150
68	68	DUMMY	0.0
69	69		0.0
70	70		0.0
71	71		0.0
72	72		0.0
73	73		0.0
74	74		0.0
75	75		0.0
76	76		0.0
77	77		0.0
78	78		0.0
79	79		0.0
80	80		0.0
81	81		0.0
82	82		0.0
83	83		0.0
84	84		0.0
85	85		0.0
86	86		0.0
87	87		0.0
88	88		0.0
89	89		0.0
90	90		0.0
91	91		0.0
92	92		0.0
93	93		0.0
94	94		0.0
95	95		0.0
96	96		0.0
97	97		0.0
98	98		0.0
99	99		0.0
100	100		0.0
101	101		0.0
102	102		0.0
103	103		0.0
104	104		0.0
105	105		0.0
106	106		0.0
107	107		0.0
108	108		0.0
109	109		0.0
110	110		0.0
111	111		0.0
112	112		0.0
113	113		0.0

```
DB6-CD3432*TPFS(D).DATA1
      1          0.,3.0
      2          1.0,2.54
      3          10.,2.49
      4          27.,2.46
      5          35.,2.46
      6          36.,2.7
      7          50.,2.7
      8          60.,3.03
      9          0.,0.

DB6-CD3432*TPFS(D).DATA2
      1          0.,3.
      2          1.,2.8
      3          2.,2.7
      4          4.,2.62
      5          6.,2.57
      6          10.,2.51
      7          15.,2.46
      8          28.,2.4
      9          50.,2.36
     10          100.,2.35
     11          0.,0.

DB6-CD3432*TPFS(D).DATA3
      1          0.,3.
      2          1.,2.8
      3          2.,2.7
      4          3.0,2.67
      5          4.,2.64
      6          6.,2.60
      7          10.,2.56
      8          15.,2.54
      9          28.,2.5
     10          29.,2.80
     11          30.,3.0
     12          60.,3.0
     13          0.,0.

DB6-CD3432*TPFS(D).DATA4
      1          0.,40.
      2          3.,45.34
      3          6.,44.34
      4          14.,44.65
      5          20.,42.57
      6          30.,43.77
      7          36.,42.42
      8          48.,42.22
      9          59.,42.58
     10          60.,40.67
     11          61.,39.13
     12          63.,34.62
     13          65.,36.86
     14          67.,35.28
     15          69.,39.24
     16          71.,37.05
     17          74.,35.83
     18          76.,36.61
     19          80.,37.85
     20          105.,39.75
     21          0.,0.
     22          0.,2.
     23          60.,1.762
     24          74.,1.656
     25          104.,2.054
     26          0.,0.

@PRT,S DATA5
```

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```
DB6-G03432*TPFS(C).DATA5
0.,3.
15.,2.754
30.,2.655
60.,2.712
90.,2.841
120.,2.958
150.,2.856
180.,3.087
190.,3.201
205.,2.841
220.,3.318
235.,3.405
250.,2.549
0.,0.

DB6-G03432*TPFS(C).DATA6
0.,3.
60.,2.575
74.,3.150
105.,3.208
0.0,0.0
0.,2.
60.,1.762
74.,1.656
104.,2.054
0.,0.

DB6-G03432*TPFS(C).DATA7
0.,40.
3.,45.34
6.,44.34
14.,44.85
20.,42.57
30.,43.77
38.,42.42
48.,42.22
59.,42.58
60.,40.67
61.,39.13
63.,34.62
65.,36.88
67.,35.28
69.,39.24
71.,37.05
74.,35.83
76.,36.61
80.,37.85
105.,39.75
0.,0.
0.,2.
60.,1.762
74.,1.656
104.,2.054
0.,0.

.PRT,S DATA8
```

```
DB6-003432*TPFS(0).DATA8
     1        0.,3.
     2        85.,2.516
     3        99.,3.289
     4        116.,3.312
     5        0.,0.
     6        0.,2.
     7        85.,1.662
     8        99.,1.910
     9        116.,2.072
    10        0.0,0.

DB6-003432*TPFS(C).DATA9
     1        0.,40.
     2        3.,43.95
     3        5.,44.54
     4        21.,43.06
     5        36.,42.58
     6        45.,43.96
     7        59.,42.46
     8        73.,42.41
     9        84.,42.41
    10        85.,40.44
    11        86.,38.4
    12        88.,35.47
    13        90.,35.33
    14        92.,35.70
    15        96.,37.95
    16        99.,36.36
    17        102.,36.95
    18        106.,37.3
    19        116.,37.46
    20        153.,42.28
    21        0.0,0.
    22        0.,2.
    23        85.,1.662
    24        99.,1.910
    25        116.,2.072
    26        0.0,0.

@PRT,S XPER
```

```
DB6-C03432*TPFS(D).XPER
      SUBROUTINE XPER
      COMMON /INTEG/MODE,ISTOP,IRMAX,NVAR
      COMMON /EDATA/HCTDAT(60),PVDAT(60),RCMDAT(50)
      COMMON/ERYO/DUME(33),DATA,DUMMC(116)
      DATA NY/'Y'/
      WRITE(6,69)
69    FORMAT(' DO YOU WISH INSTRUCTIONS (Y/N)')
      READ(5,88)IA
88    FORMAT(A1)
      IF(IA.NE.NY)GO TO 17
      WRITE(6,90)
90    FORMAT(' DATA CAN BE SELECTED FROM THE FOLLOWING STUDIES',/
     1' 1= BEDREST PLASMA VOLUME (MORSE,1969)',/
     2' 2= BED REST PLASMA VOLUME (IDEALIZED)',/
     3' 3= BED REST PLASMA VOLUME (BCM-JOHNSON,1976)',/
     4' 4= BEDREST HCT(BCM-JOHNSON,1976)',/
     5' 5= ALTITUDE HYPOXIA PLASMA VOLUME (BUDERER,1973)',/
     6 ' 6= SKYLAB 3 PLASMA VOLUME',/
     7' 7= SKYLAB 3 HCT (PERIPHERAL)',/
     8 ' 8= SKYLAB 4 PLASMA VOLUME',/
     9' 9= SKYLAB 4 HCT (PERIPHERAL)',/
     &' 10= INPUT PLASMA VOLUME',/
     &' 11= INPUT PERIPHERAL HEMATOCRIT'/)
17    WRITE(6,91)
91    FORMAT(' ENTER EXPERIMENTAL DATA CODE WANTED')
      READ(5,92)ID
92    FORMAT()
      GO TO (1,2,3,4,5,6,7,8,9,10,11,21),ID
21    GO TO 17
1     CALL ERTRAN(6,'@ADD .DATA1 . ')
      GO TO 22
2     CALL ERTRAN(6,'@ADD .DATA2 . ')
      GO TO 22
3     CALL ERTRAN(6,'@ADD .DATA3 . ')
      GO TO 22
4     CALL ERTRAN(6,'@ADD .DATA4 . ')
      GO TO 22
5     CALL ERTRAN(6,'@ADD .DATA5 . ')
      GO TO 22
6     CALL ERTRAN(6,'@ADD .DATA6 . ')
      GO TO 22
7     CALL ERTRAN(6,'@ADD .DATA7 . ')
      GO TO 22
8     CALL ERTRAN(6,'@ADD .DATA8 . ')
      GO TO 22
9     CALL ERTRAN(6,'@ADD .DATA9 . ')
      GO TO 22
10    WRITE(6,93)
93    FORMAT(' ENTER DAY, PLASMA VOLUME (L)  (C/R TO END)')
      GO TO 22
11    WRITE(6,94)
94    FORMAT(' ENTER DAY, PERIPHERAL HCT  (C/R TO END)')
22    GO TO (12,12,12,13,12,12,13,12,13,12,13),ID
12    DATA=1.
      DO 112 I=1,60,2
      READ(5,92)(PVDAT(II+I-1),II=1,2)
```

```
      N=I+1
      IF(PVDAT(N).GT.5.)GO TO 111
      IF(PVDAT(N).LE.0.)GO TO 111
112   CONTINUE
      GO TO 111
13    MODE=2
      DO 113 I=1,60,2
      READ(5,92)(HCTDAT(II+I-1),II=1,2)
      N=I+1
      IF(HCTDAT(N).GT.100.)GO TO 111
      IF(HCTDAT(N).LE.0.)GO TO 111
113   CONTINUE
111   GO TO (14,14,14,14,14,15,15,15,15,14,14),ID
15    DO 115 I=1,60,2
      READ(5,92)(RCMDAT(II+I-1),II=1,2)
      N=I+1
      IF(RCMDAT(N).GT.5.)GO TO 14
      IF(RCMDAT(N).LE.0.)GO TO 14
115   CONTINUE
14    CONTINUE
      WRITE(6,888)(PVDAT(IF),IF=1,N)
888   FORMAT(1H ,10F7.2)
      RETURN
      END
```

@PRT,S EXPLOR